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ABSTRACT

Provided in this lesson is introductory material on sand and surfaced sludge drying beds. Typical construction and operation, proper maintenance, and safety procedures are considered. The lesson includes an instructor's guide and student workbook. The instructor's guide contains a description of the lesson, estimated presentation time, instructional materials list, suggested sequence of presentation, reading lists, objectives, lecture outline, narrative of the slide/tape program used with the lesson, and student worksheet (with answers). The student workbook contains plant flow diagrams, objectives, glossary, discussion of drying beds, references, and worksheet. (JN)

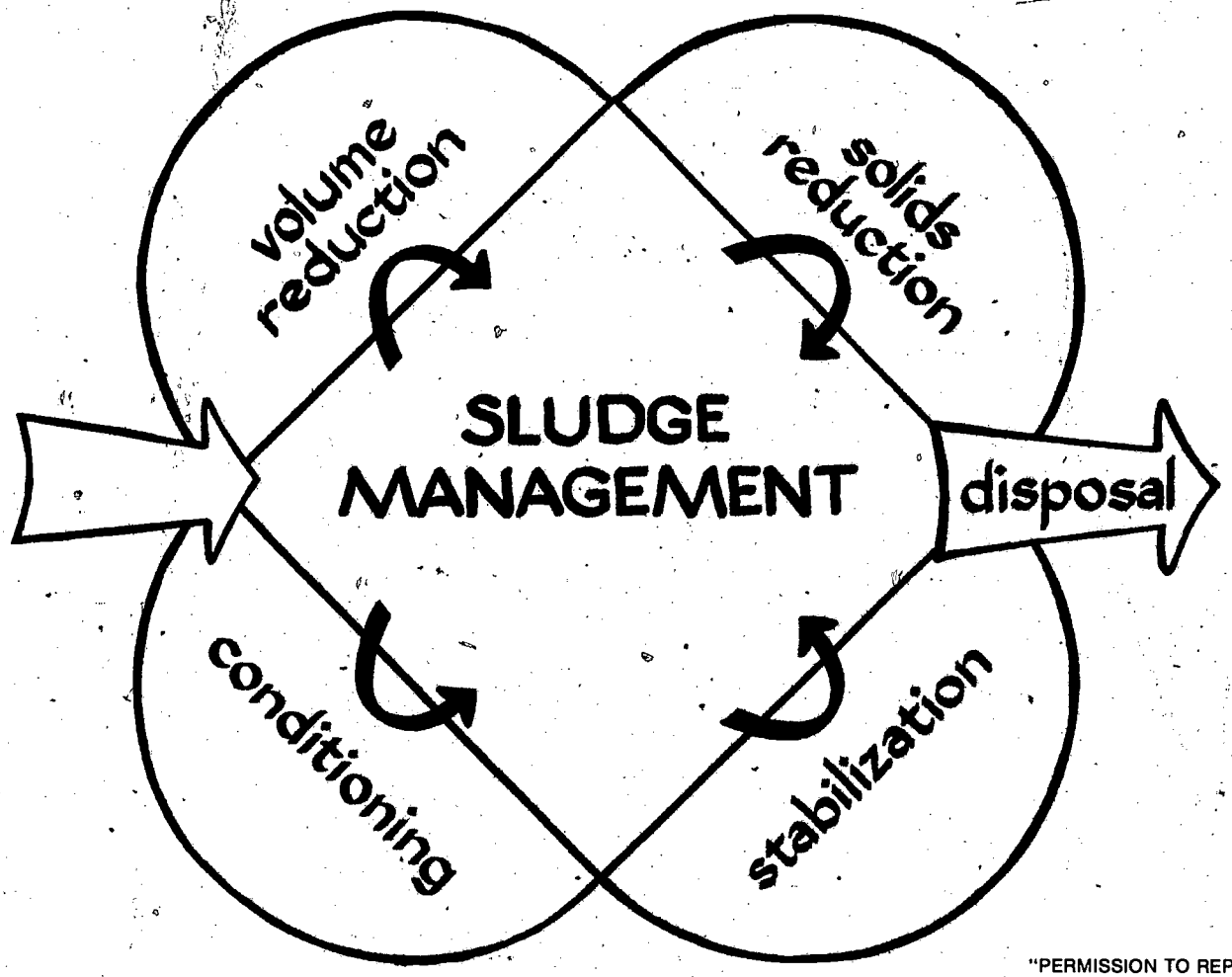
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

DRYING BEDS



INSTRUCTOR'S GUIDE

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

DRYING BEDS

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Developed Under:
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August, 1980

DRYING BEDS

CONTENTS

DRYING BEDS

Lesson Description

This lesson is an introduction to sludge drying beds. The module discusses both sand and surfaced drying beds. It covers typical construction and operation. Proper maintenance and safety procedures are also pointed out.

The student should review the following modules before undertaking this lesson: "Sludge Characteristics", "Sludge Conditioning", and "Anaerobic Digestion". It may also be prudent to review the module on "Planning Considerations".

This module may be presented in either a slide/tape format or lecture mode, utilizing only the slide set.

Estimated Time

Student Preview	5 - 10 Minutes
Presentation of Material	20 - 30 Minutes
Worksheet	10 - 15 Minutes
Correct Worksheet	10 - 15 Minutes

Instructional Materials List

1. Student text, "Drying Beds".
2. Slide/tape set, "Drying Beds".
3. Slide projector, 35mm carousel.
4. Wollensak cassette player with synchronization to slide projector.
5. Projection screen
6. Samples of dried sludge.
7. Samples of gravel and sand.

Suggested Sequence of Presentation

1. Assign reading of objectives and glossary.
2. Show slide/tape program or lecture using slides.
3. Discuss any questions arising from presentation.
4. Assign worksheet.
5. Correct worksheet.

DRYING BEDS

Required Reading

Student text, "Drying Beds".

Reference Reading

WPCF Manual of Practice No. 11, "Operation of Wastewater Treatment Plants", 1976.

"Sludge Treatment and Disposal" - Process Design Manual, 1979, EPA 625/1-79-011.

EPA Course #166, "Sludge Characteristics", "Sludge Conditioning", "Planning Considerations", "Anaerobic Digestion".

DRYING BEDS

Objectives

Upon completion of this lesson the student should be able to do the following:

1. Recall drying beds are typically used for small to medium sized plants, less than 5 MGD.

2. Given an unlabeled diagram of a drying bed, correctly label the following areas:
   a. Underdrain
   b. Gravel support
   c. Sand

3. State the typical slduge application rate for a drying bed to be 12 -18" deep.

4. Recall that drying beds cause dewatering for two reasons:
   a. Evaporation
   b. Drainage

5. Recall that highly odorous sludges, such as thermally conditioned sludge, should not be placed on a drying bed.

6. List three factors affecting the operation and performance of a drying bed. The acceptable answers include:
   a. Sludge characteristics
   b. Conditioning
   c. Climate
   d. Application rates and depth
   e. Removal techniques

7. Recall htat, for sludge to lose water through the sand bed, the sludge solids must flocculate and release free water.

8. State one of two problems associated with overdosing sludges with conditioners before applying to a drying bed. Acceptable answers include:
   a. Sand plugs with polymer or other conditioning chemical.
   b. Large, fast-settling floc may blind the sand.

9. Recall that a plugged drying bed dries by evaporation rater than by drainage and evaporation.

10. State the effect of precipitation, temperature, humidity and wind on drying rate.

11. Recall two of three factors over which there is little or no control. The acceptable answers include:

    a. Sludge type characteristics
    b. Climate
    c. Physical size of bed

12. Recall two of three factors over which there is control. The acceptable answers include:

    a. Conditioning
    b. Depth of application
    c. Dewatered sludge removal techniques

13. Recall that loading is expressed as lbs. solids/yr./sq. ft.

14. Recall that covered beds can be loaded at a higher rate than open beds.

15. Recall that as loading decreases, dewatering time decreases and the potential for blinding increases.

16. State two of three precautions to be taken when removing dewatered sludge from a sand bed. The acceptable answers include:

    a. Don't compact bed.
    b. Avoid heavy equipment.
    c. Remove as little of the sand as possible.

17. Recall that a compacted bed causes lower drainage rates and longer drying time.

18. List three of five procedures which should be followed in operating a drying bed. The acceptable answers include:

    a. Apply evenly.
    b. Don't upset snad surface.
    c. Flush sludge piping with clean water.
    d. Avoid sand loss.
    e. Scrape and smooth surface prior to application.

19. Recall that digested primary sludge can be loaded heavier than digested secondary sludge.

20. State that a major advantage of surfaced drying beds is that they can be mechanically cleaned.

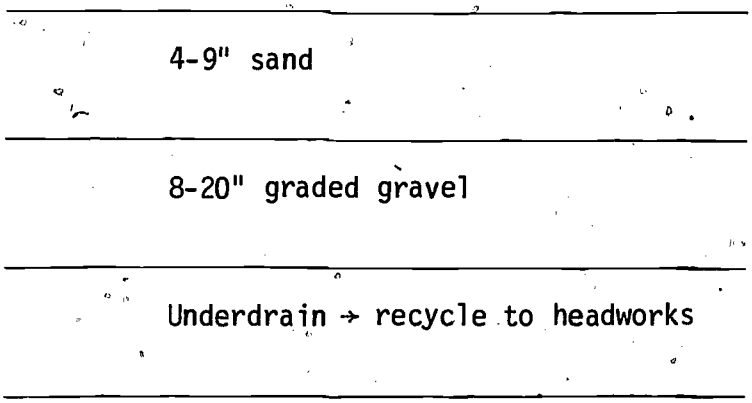
21. Recall that smoking should not be permitted around drying beds because of the potential for explosive gases being present.

DRYING BEDS - LESSON OUTLINE

I. SAND DRYING BEDS

A. Small - Medium Plants < 5MGD

B. Typical Construction



C. Application

1. Sludge applied 12 - 18" deep
2. Dewaters → drainage
   → evaporation
3. Thermal conditioned sludges- odorous - not used

II. FACTORS AFFECTING SAND DRYING BEDS

A. Design, use, performance affected by:

1. Sludge type
2. Conditioning
3. Climate
4. Application rates and depths
5. Dewatered sludge removal techniques

B. Similarity with mechanical dewatering

1. Type of sludge, conditioning - determines degree of dewatering and operation of beds.

C. Conditioning - most H_2O lost through sand. Sludge must flocculate and release free H_2O.

1. Prevent overdosing for two reasons.

a. Sand pores plug up with polymer.

b. Large floc settling too fast may blind the sand.

2. Blinded sand bed - won't drain - dries only by evaporation.

3. Climate

a. After drainage, only water lost is through evaporation.

b. Cold, rainy climates → covered greenhouse

(1) Must be well-ventilated.

c. Precipitation decreases drying rate.

d. High temperatures increase drying rate.

e. High humidity decreases drying rate.

f. High wind increases drying rate.

4. Little or no control:

a. Sludge type and characteristics

b. Climate

c. Physical size of beds

5. Control

a. Depth of sludge application

b. Dewatered sludge removal techniques

c. Conditioning

III. OPERATING GUIDELINES

A. Loading

1. 10 - 35 lbs. solids/yr./sq. ft. = Open Beds

2. 20 - 45 lbs. solids/yr./sq. ft. - Covered Beds

B. Loading rate decreases dewatering time, potential for blinding increases.

1. The decision of whether light loading and frequent removal or heavy loading and less frequent removal is best should be based on operating experience.

C. Sludge Removal

1. Remove as little of sand as possible.

2. Don't compact bed.

3. Avoid heavy equipment.

4. Compacted bed = reduced drainage rates, longer drying time.

IV. NORMAL OPERATING PROCEDURE

A. Apply evenly.

B. Minimal upsetting of bed surface.

1. Via inlet distribution assembly consisting of troughs and weirs

C. Flush sludge out of pipe.

1. Avoid gas production.

D. Remove sludge from beds when dry enough to be easily handled - otherwise sand loss.

E. Scrape and smooth surface in preparation for more sludge.

V. TYPICAL PERFORMANCE

Sludge Type	Loading lb ss/sq ft Open	Covered	Dewatered Sludge Conc. %	% Solids Capture
Digested Primary	20-35	20-45	30-70	95-99
Digested Secondary	10-20	10-25	30-50	95-99
Digested Combined	10-25	10-35	30-70	95-99

Performance depends on many uncontrollable variables.

VI. SURFACED SLUDGE DRYING BEDS

A. Rationale - sand beds must be manually cleaned.

1. Blacktop or concrete base allows use of skip loaders.

VII. LAYOUT OF SURFACED DRYING BEDS

A. Allows use of mechanical removal equipment.

B. Shape

1. Rectangle

2. 40 - 50 feet X 100 - 200 feet

3. 2' high retaining wall

C. Size

1. Such that one bed will fill to 18" in 8 hours.

D. Drain line - down center (4 - 6" diameter) 18 - 30" deep

1. Perforated pipe or pulled joints

2. Drain trench filled with sand and gravel - filters drainage water.

E. No smoking around drying bed.

DRYING BEDS

Narrative

Slide #

1. This module discusses the use of drying beds for dewatering sludge. The theory, structure and operation of drying beds is discussed.

2. The module was written by Mr. Paul H. Klopping. The instruction design was done by Priscilla Hardin. Mr. Klopping was also the project director.

3. Sand drying beds are a typical method of dewatering sludge in plants of 5 MGD or less and occasionally, in larger plants, drying beds are sued for all or part of the dewatering needs.

4. Because of the large number of small to medium-sized plants, drying beds are the most common method of sludge dewatering.

5. Land availability limits the use of drying beds in many larger facilities. Climatic conditions and land requirements are considerations which limit their use.

6. Two general types of drying beds are used: the sand drying bed and surfaced drying bed.

7. The sand drying bed is the most common and is built on an underdrain and gravel support. The surfaced drying bed uses a paved surface and underdrain.

8. Sand drying beds typically have three main parts. First there is an underdrain, which collects water draining from the sludge and recycles it back to the headworks of the plant.

9. On top of the underdrain is 8-20" of graded gravel which acts as a support for the sand bed.

10. 4-9" of sand is placed on top of the gravel.

11. Digested or conditioned sludge is applied evenly to the sand surface, to a depth of 12-18". The sludge then dewaters in two phases:

12. drainage occurs as water travels downward through the sand bed, gravel support and out the underdrain. Most drainage occurs in the first few days

13. and then further dewatering is dependent on evaporation.

14. Because evaporation is a major dewatering force, climate has a significant effect on drying bed operation.

15. Covered beds, much like greenhouses, are one method of reducing the effect of climate.

16. Drying beds should not be sued for highly odorous sludges, such as those that are thermally conditioned. Raw or poorly digested sludge is not suitable for dewatering on open drying beds because of these problems.

17. There are five factors which influence the operation of sand drying beds. These are: Sludge characteristics, Conditioning, Climate, Application rates and depths, Sludge removal techniques.

18. Whether sludge is dewatered by mechanical devices or drying beds the process is strongly influenced by the sludge's characteristics and conditioning.

19. Conditioning sludge with polymer causes sludge to flocculate and release free water, which then drains through the sand.

20. Caution must be exercised when using polymer. It is possible for the sand pores to become plugged if too much polymer has been applied. Also,

21. if too large a floc is produced, the floc may settle too fast, plugging the sand surface before the water has a chance to drain away from the solids.

22. In either case, the sand bed becomes blinded and won't drain properly. When blinding occurs,

23. drying takes place only by evaporation, greatly increasing the time sludge must stay on the bed before it is "liftable" or dry enough to be removed.

24. Climate most significantly influences the evaporation of water from the bed. Precipitation and humidity increase drying time while high timperatures and wind reduce it.

25. In cold, rainy areas drying beds are impractical without adequately ventilated covering.

26. The factors affecting drying beds over which there is little or no control are the sludge type and it's characteristics, the climate and the area of the beds.

27. Some control can be achieved by using some method of sludge conditioning, varying the depth of sludge application, and in selecting the method of removing dewatered sludge from the bed.

28. Loading on a drying bed is usually expressed in terms of pounds of solids applied per year per square foot of bed area. The loading is unique to each plant,

29. but as a general rule open beds are loaded in the range of 10-35 lbs and covered beds at a rate of 20-45 lbs solids/year square foot.

30. As loading rate decreases, the dewatering time is reduced as well as the potential for blinding the sand bed.

31. Operating experience at a facility is the best guide in reaching the decision to use light loadings and frequent removal or heavy loading and less frequent removal.

32. Under normal operations, five steps should be followed in properly using a drying bed. First, sludge should be applied evenly to the surface of the bed.

33. The sludge should be applied in such a way that the sand surface is not disturbed. This is accomplished by means of splash blocks and a suitable inlet distribution assembly consisting of troughs and weirs which evenly distribute sludge onto the bed.

34. Once sludge is applied, the piping should be flushed with fresh water to avoid gas production.

35. Remove dried sludge from the bed when it is dry enough to be easily handled.

36. Otherwise excessive amounts of sand cling to the sludge resulting in excessive losses of sand. When the sludge is dry enough, remove it carefully so as not to disturb the sand, underdrains or other structures.

37. Once the dried sludge has been removed, rake and smooth the sand surface for the next application. This helps to level out the bed and open pores in the sand required for drainage.

38. Several precautions must be exercised in removing dewatered sludge from the drying bed. First, as little of the sand as possible should be removed when sludge is lifted off the bed surface.

39. The method of removal shouldn't compact the bed, because this restricts drainage on subsequent sludge applications. Heavy equipment for removal should be avoided. It may damage the underdrain system in addition to compacting the sand surface. As the bed becomes compacted, drainage rates are reduced and consequently longer drying times are required.

40. Performance of drying beds depends on several factors over which the operator has lettle control: Sludge type, climate, and bed area.

41. Digested primary sludge can be loaded heavier than digested secondary sludge.

42. This is due to the fact that secondary sludge has a higher amount of bound water which is trapped in the sludge particles.

43. Since digested primary sludge is more drainable, it can be loaded onto a bed at a higher rate.

44. Surfaced drying beds are built with an asphalt or concrete base instead of sand.

45. This allows the use of front-end loaders for sludge removal, whereas sand beds are often manually cleaned. The fact that surfaced beds can be mechanically cleaned is a major advantage.

46. Surfaced beds are rectangular and enclosed by a 2 foot high retaining wall.

47. They are sized so that one bed can be filled to a depth of 12-18" in 8 hours.

48. A drain line is installed in a trench in the center of the bed. This line is 4-6" in diameter and is constructed of perforated pipe or pipe with pulled joints.

49. The drainage pipe is placed in a trench 18-30" deep and filled with sand and gravel, providing a filter for draining water away from the sludge.

50. Essentially, the surfaced bed is operated much like a sand bed, with the exception that surfaced beds are more often mechanically cleaned.

51. Smoking should never be allowed around drying beds because of the potential presence of explosive gases. This rule holds for other areas of the plant where sludge gasification may occur.

52. Because of simple design features and operation, drying beds have been the most common method of sludge dewatering.

53. They have low energy requirements in relation to other dewatering processes, and are considered an important dewatering method where climate and land availability are suitable.

References

WPCF Manual of Practice No. 11, "Operation of Wastewater Treatment Plants", 1976.

"Sludge Treatment and Disposal" - Process Design Manual, 1979, EPA 625/1-79-011.

EPA Course #166, "Sludge Characteristics", "Sludge Conditioning", "Planning Considerations", "Anaerobic Digestion".

DRYING BEDS - WORKSHEET

1. In what size plant are drying beds usually used?

   X a. Small-medium, less than 5 MGD

   _____ b. 10 - 30 MGD

   _____ c. Large, more than 50 MGD

2. What is the typical sludge application rate for a drying bed?

   _____ a. 2 - 4"

   _____ b. 4 - 8"

   X c. 12 - 18"

   _____ d. 24 - 36"

3. A drying bed causes the sludge to dewater for two reasons. What are they?

   _____ a. Biological absorption of the water.

   X b. Evaporation

   _____ c. Transpiration

   X d. Drainage

   _____ e. Runoff

4. Choose three factors affecting the operation and performance of a drying bed.

   X a. Climate

   _____ b. NPDES Permit

   X c. Application rates and depth

   X d. Conditioning

5. Overdosing sludges with conditioners before applying to a drying bed may cause several problems. Choose two.

   X a. Sludge dewaters too fast, blinding the sand.

   X b. Sand may plug up with conditioners.

   _____ c. Conditioners cause the sand to break down and compact.

   _____ d. Conditioners cause odor problems.

   _____ e. Conditioners cause weeds to grow.

6. In utilizing drying beds, there are several things over which the operator has no control. Choose two.

   ____ a. Application rates
   __X__ b. Sludge type
   __X__ c. Climate
   __X__ d. Bed Size
   ____ e. Conditioning

7. Choose two factors that the operator can control in drying bed operations.

   __X__ a. Removal techniques
   __X__ b. Application rates
   __X__ c. Conditioning
   ____ d. Climate
   ____ e. Sludge type

8. Which drying bed can be loaded at the highest rate?

   __X__ a. Covered
   ____ b. Uncovered

9. As loading on a drying bed decreases, the dewatering time:

   ____ a. Increases
   __X__ b. Decreases

   Therefore, the potential for blinding:

   __X__ a. Increases
   ____ b. Decreases

10. Choose two precautions to be taken when removing dry sludge from a sand bed.

    ____ a. Be sure to remove the top layer of sand to expose a new surface.
    ____ b. Smooth out the surface with a road grader or bulldozer.
    __X__ c. Remove only dried sludge, no sand.
    __X__ d. Rake the bed in preparation for the new application.
    __X__ e. Don't damage the underdrain.

11. Select three procedures to be followed in operating a drying bed.

_____ a. Apply sludge to the bed as fast as possible.

_X_ b. Flush piping with fresh water after applying sludge.

_____ c. Remove 10 - 20% of the sand when removing the dried sludge.

_X_ d. Scrape and smooth surface prior to application.

_X_ e. Avoid sand loss.

12. Which sludge type can be loaded the heaviest on a drying bed?

_X_ a. Digested primary sludge.

_____ b. Digested secondary sludge.

13. What is the major advantage of surfaced drying beds?

_____ a. Less costly to build.

_____ b. Sludge dries faster.

_X_ c. Can be mechanically cleaned.

_____ d. Won't allow tomatoes to grow.

_____ e. Doesn't allow foul odors to accumulate.

14. Why should smoking be prohibited around drying beds?

_____ a. The underdrain may become clogged with cigarette butts.

_____ b. It is against the advice of the Surgeon General.

_____ c. The operator should not put anything in his mouth when handling sludge because pathogens may be present.

_X_ d. Explosive gases may be present.

_____ e. None of the above.

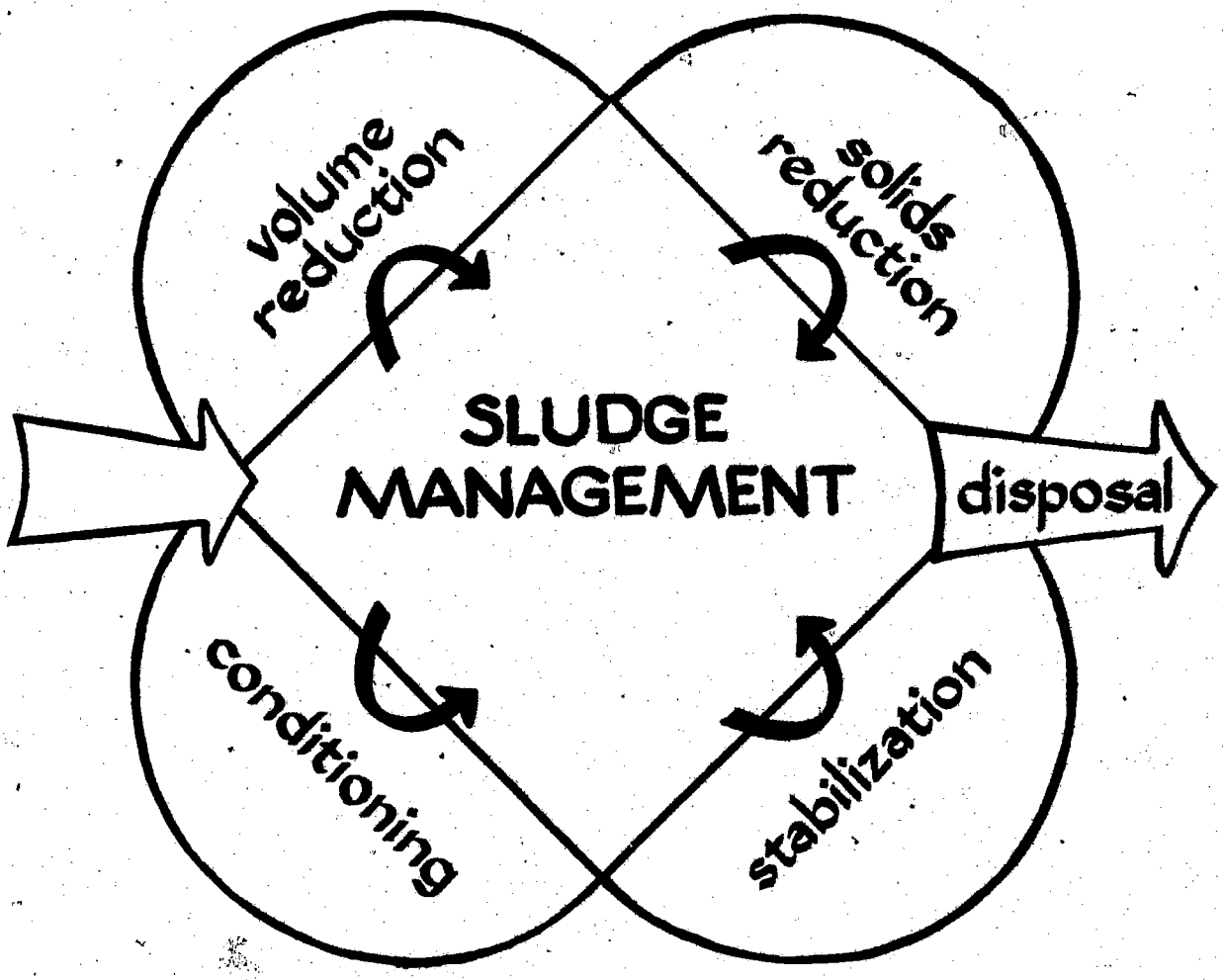
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

DRYING BEDS



STUDENT WORKBOOK

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

DRYING BEDS

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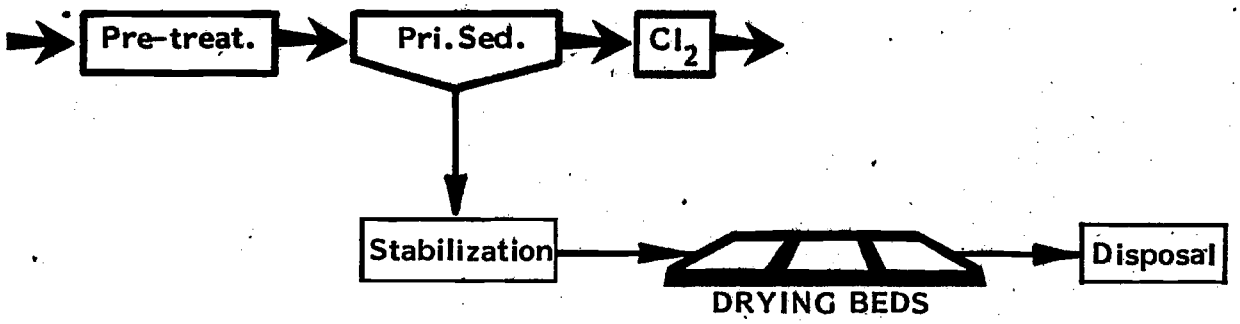
DRYING BEDS

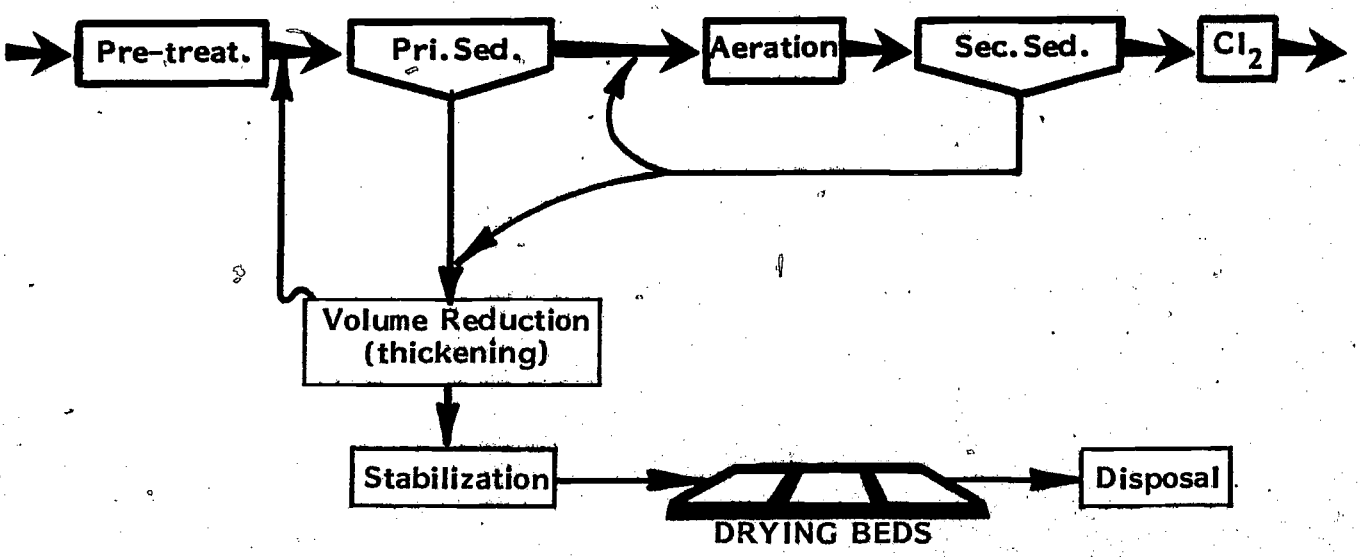
CONTENTS

PLANT FLOW DIAGRAMS

PRIMARY PLANT



SECONDARY PLANT



DRYING BEDS

Objectives

Upon completion of this lesson the student should be able to do the following:

1. Recall drying beds are typically used for small to medium sized plants, less than 5 MGD.
2. Given an unlabeled diagram of a drying bed, correctly label the following areas:
   a. Underdrain
   b. Gravel support
   c. Sand
3. State the typical sludge application rate for a drying bed to be 12 - 18" deep.
4. Recall that drying beds cause dewatering for two reasons:
   a. Evaporation
   b. Drainage
5. Recall that highly odorous sludges, such as thermally conditioned sludge, should not be placed on a drying bed.
6. List three factors affecting the operation and performance of a drying bed. The acceptable answers include:
   a. Sludge characteristics
   b. Conditioning
   c. Climate
   d. Application rates and depth
   e. Removal techniques
7. Recall that, for sludge to lose water through the sand bed, the sludge solids must flocculate and release free water.
8. State one of two problems associated with overdosing sludges with conditioners before applying to a drying bed. Acceptable answers include:
   a. Sand plugs with polymer or other conditioning chemical.
   b. Large, fast-settling floc may blind the sand.
9. Recall that a plugged drying bed dries by evaporation rather than by drainage and evaporation.
10. State the effect of precipitation, temperature, humidity and wind on drying rate.
11. Recall two of three factors over which there is little or no control. The acceptable answers include:
    a. Sludge type characteristics
    b. Climate
    c. Physical size of bed

12. Recall two of three factors over which there is control. The acceptable answers include:

    a. Conditioning
    b. Depth of application
    c. Dewatered sludge removal techniques

13. Recall that loading is expressed as lbs. solids/yr./sq. ft.

14. Recall that covered beds can be loaded at a higher rate than open beds.

15. Recall that as loading decreases, dewatering time decreases and the potential for blinding increases.

16. State two of three precautions to be taken when removing dewatered sludge from a sand bed. The acceptable answers include:

    a. Don't compact bed.
    b. Avoid heavy equipment.
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17. Recall that a compacted bed causes lower drainage rates and longer drying time.

18. List three of five procedures which should be followed in operating a drying bed. The acceptable answers include:

    a. Apply evenly.
    b. Don't upset sand surface.
    c. Flush sludge piping with clean water.
    d. Avoid sand loss.
    e. Scrape and smooth surface prior to application.

19. Recall that digested primary sludge can be loaded heavier than digested secondary sludge.

20. State that a major advantage of surfaced drying beds is that they can be mechanically cleaned.

21. Recall that smoking should not be permitted around drying beds because of the potential for explosive gases being present.

DRYING BEDS

GLOSSARY

Blinding - The plugging of pores or open spaces which prohibits the free movement of water through a material.

Bound Water - Water associated with sludge solids which are not readily released by the force of gravity. This water is "trapped" in sludge floc.

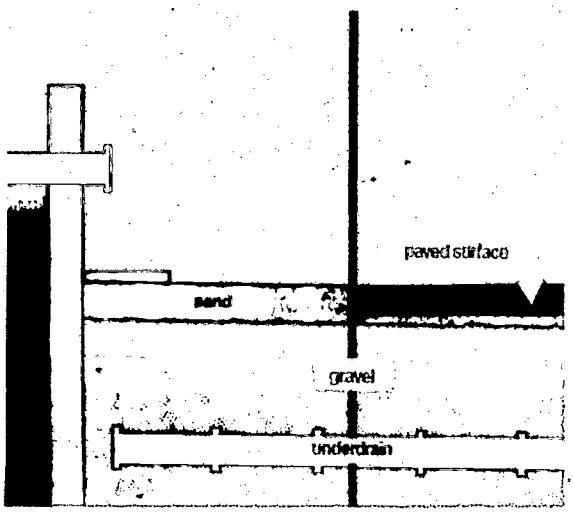
Evaporation - The process by which water changes from the liquid state to a vapor state.

Gasification - The transformation of sewage solids into gas in the decomposition of sewage.

Splash Block - A structure, usually concrete, located at the discharge of a pipe. It is intended to spread or "fan out" a stream of high velocity and/or volume over a large area so as to avoid surface erosion or damage.

Underdrain - A drain tile or pipe network which collects water from a layer above.

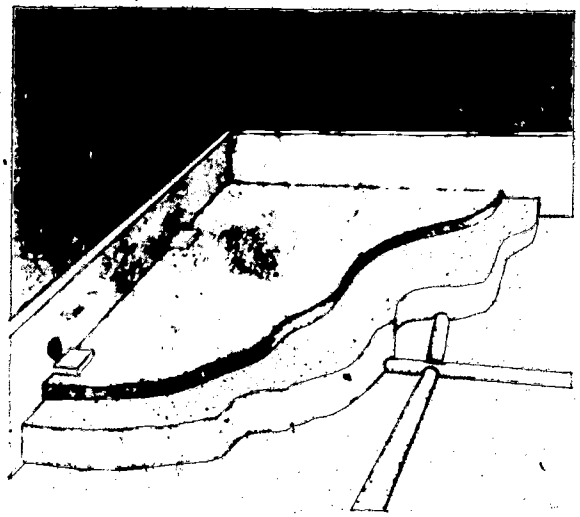
SAND DRYING BEDS



Sand drying beds are a typical method of dewatering sludge in plants of 5 MGD or less and occasionally, in larger plants, drying beds are used for all or part of the dewatering needs. Because of the large number of small to medium-sized plants, drying beds are the most common method of sludge dewatering. Land availability limits the use of drying beds in many larger facilities. Climatic conditions and land requirements are considerations which limit their use.

Two general types of drying beds are used: the sand drying bed and surfaced drying bed. The sand drying bed is the most common and is build on an underdrain and gravel support. The surfaced drying bed uses a paved surface and underdrain.

SAND BED

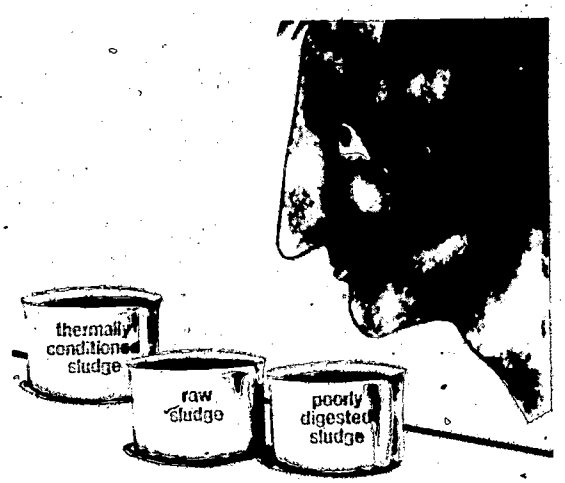


Sand drying beds typically have three main parts: an underdrain, which collects water draining from the sludge and recycles it back to the headworks of the plant. On top of the underdrain is 8-20" of graded gravel which acts as a support for the sand bed. 4-9" of sand is placed on top of the gravel.

Digested or conditioned sludge is applied evenly to the sand surface, to a depth of 12-18". The sludge then dewaters in two phases: drainage occurs as water travels downward through the sand bed, gravel support and out the underdrain. Most drainage occurs in the first few days and then further dewatering is dependent on evaporation. Because evaporation is a major dewatering force,

Effect of Climate

climate has a significant effect on drying bed operation. Covered beds, much like greenhouses, are one method of reducing the effect of climate.



Drying beds should not be used for highly odorous sludges, such as those that are thermally conditioned, because of the odor nuisances. Raw or poorly digested sludge is not suitable for dewatering on open drying beds because of odor problems.

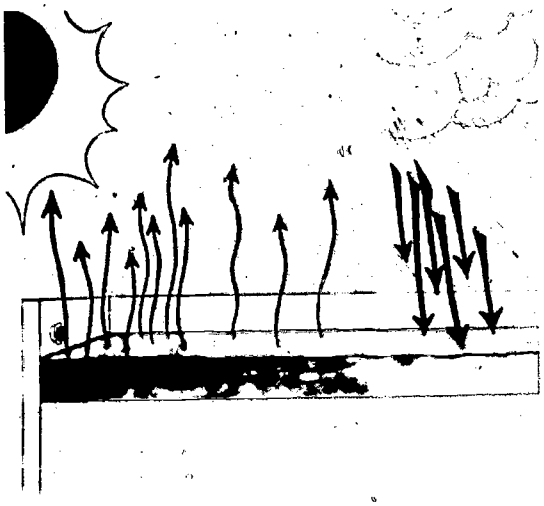
There are five factors which influence the operation of sand drying beds. These are:

- Sludge characteristics
- Conditioning
- Climate
- Application rates and depths
- Sludge removal techniques

Whether sludge is dewatered by mechanical devices or drying beds the process is strongly influenced by the sludge's characteristics and conditioning.

SAND BED BLINDING

Conditioning sludge with polymer causes sludge to flocculate and release free water, which then drains through the sand. Caution must be exercised when using polymer. It is possible for the sand pores to become plugged if too much polymer has been applied. Also, if too large a floc is produced, the floc may settle too fast, plugging the sand surface before the water has a chance to drain away from the solids. In either case, the sand bed becomes blinded and won't drain properly. When blinding occurs drying takes place only by evaporation, greatly increasing the time sludge must



stay on the bed before it is "liftable" or dry enough to be removed.

Climate most significantly influences the evaportation of water from the bed. Precipitation and humidity increase drying time while high temperatures and wind reduce it. In cold, rainy areas drying beds are impractical without adequately ventilated covering.

The factors affecting drying beds over which there is little or no control are the sludge type and it's characteristics, the climate and the area of the beds. Some control can be achieved by using some method of sludge conditioning, varying the depth of sludge application, and in selecting the method of removing dewatered sludge from the bed.

LOADING
***lbs/yr/sq ft**

Loading on a drying bed is usually expressed in terms of pounds of solids applied per year per square foot of bed area. The loading is unique to each plant, but as a general rule open beds are loaded in the range of 10-35 lbs and covered beds at a rate of 20-45 lbs solids/year/square foot.

As loading rate decreases, the dewatering time is reduced as well as the potential for blinding the sand bed. Operating experience at a facility is the best guide in reaching the decision to use light loadings and frequent removal or heavy loading and less frequent removal.

Under normal operations, five steps should be followed in properly using a drying bed. First, sludge should be applied evenly to the surface

NORMAL OPERATIONS
* Apply evenly
* Flush piping
* Adequate drying time
* Remove sludge
* Rake surface

of the bed. The sludge should be applied in such a way that the sand surface is not disturbed. This is accomplished be means of splash blocks and a suitable inlet distribution assembly consisting of troughs and weirs which evenly distribute sludge onto the bed. Once sludge is applied, the piping should be flushed with fresh water to avoid gas production.

Remove dried sludge from the bed when it is dry enough to be easily handled. Otherwise excessive amounts of sand cling to the sludge resulting in excessive losses of sand. When the sludge is dry enough, remove it carefully so as not to disturb the sand, underdrains or other structures.

Once the dried sludge has been removed, rake and smooth the sand surface for the next application. This helps to level out the bed and open pores in the sand required for drainage.

PRECAUTIONS
* Don't remove sand
* Don't compact bed
* Don't damage underdrains

Several precautions must be exercised in removing dewatered sludge from the drying bed. First, as little of the sand as possible should be removed when sludge is lifted off the bed surface. The method of removal shouldn't compact the bed, because this restricts drainage on subsequent sludge applications. Heavy equipment for removal should be avoided which may damage the underdrain system in addition to compacting the sand surface. As the bed becomes compacted, drainage rates are reduced and consequently longer drying times are required.

Performance of drying beds depends on several factors over which the operator has little control: Sludge type, climate, and bed area.

PRIMARY vs SECONDARY SLUDGE

Digested primary sludge can be loaded heavier than digested secondary sludge. This is due to the fact that secondary sludge has a higher amount of bound water which is trapped in the sludge particles. Since digested primary sludge is more drainable, it can be loaded onto a bed at a higher rate.

SURFACED BEDS
* Asphalt base
* Mechanically cleaned

Surfaced drying beds are built with an asphalt or concrete base instead of sand. This allows the use of front-end loaders for sludge removal, whereas sand beds are often manually cleaned. The fact that surfaced beds can be mechanically cleaned is a major advantage.

Surfaced beds are rectangular and enclosed by a 2 foot high retaining wall. They are sized so that one bed can be filled to a depth of 12-18" in 8 hours.

A drain line is installed in a trench in the center of the bed. This line is 4-6" in diameter and is constructed of perforated pipe or pipe with pulled joints. The drainage pipe is placed in a trench 18-30" deep and filled with sand and gravel, providing a filter for draining water away from the sludge. Essentially, the surfaced bed is operated much like a sand bed, with the exception that surfaced beds are more often mechanically cleaned.

SAFETY

Smoking should never be allowed around drying beds because of the potential presence of explosive gases. This rule holds for other

areas of the plant where sludge gasification may occur.

Because of simple design features and operation, drying beds have been the most common method of sludge dewatering. They have low energy requirements in relation to other dewatering processes, and are considered an important dewatering method where climate and land availability are suitable.

References

WPCF Manual of Practice No. 11, "Operation of Wastewater Treatment Plants", 1976.

"Sludge Treatment and Disposal" - Process Design Manual, 1979, EPA 625/1-79-011.

EPA Course #166, "Sludge Characteristics", "Sludge Conditioning", "Planning Considerations", "Anaerobic Digestion".

DRYING BEDS - WORKSHEET

1. In what size plant are drying beds usually used?

   _____ a. Small-medium, less than 5 MGD

   _____ b. 10 - 30 MGD

   _____ c. Large, more than 50 MGD

2. What is the typical sludge application rate for a drying bed?

   _____ a. 2 - 4"

   _____ b. 4 - 8"

   _____ c. 12 - 18"

   _____ d. 24 - 36"

3. A drying bed causes the sludge to dewater for two reasons. What are they?

   _____ a. Biological absorption of the water.

   _____ b. Evaporation

   _____ c. Transpiration

   _____ d. Drainage

   _____ e. Runoff

4. Choose three factors affecting the operation and performance of a drying bed.

   _____ a. Climate

   _____ b. NPDES Permit

   _____ c. Application rates and depth

   _____ d. Conditioning

5. Overdosing sludges with conditioners before applying to a drying bed may cause several problems. Choose two.

   _____ a. Sludge dewaters too fast, blinding the sand.

   _____ b. Sand may plug up with conditioners.

   _____ c. Conditioners cause the sand to break down and compact.

   _____ d. Conditioners cause odor problems.

   _____ e. Conditioners cause weeds to grow.

6. In utilizing drying beds, there are several things over which the operator has no control. Choose two.

   _____ a. Application rates

   _____ b. Sludge type

   _____ c. Climate

   _____ d. Bed Size

   _____ e. Conditioning

7. Choose two factors that the operator can control in drying bed operations.

   _____ a. Removal techniques

   _____ b. Application rates

   _____ c. Conditioning

   _____ d. Climate

   _____ e. Sludge type

8. Which drying bed can be loaded at the highest rate?

   _____ a. Covered

   _____ b. Uncovered

9. As loading on a drying bed decreases, the dewatering time:

   _____ a. Increases

   _____ b. Decreases

   Therefore, the potential for blinding:

   _____ a. Increases

   _____ b. Decreases

10. Choose two precautions to be taken when removing dry sludge from a sand bed.

    _____ a. Be sure to remove the top layer of sand to expose a new surface.

    _____ b. Smooth out the surface with a road grader or bulldozer.

    _____ c. Remove only dried sludge, no sand.

    _____ d. Rake the bed in preparation for the new application.

    _____ e. Don't damage the underdrain.

11. Select three procedures to be followed in operating a drying bed.

_____ a. Apply sludge to the bed as fast as possible.

_____ b. Flush piping with fresh water after applying sludge.

_____ c. Remove 10 - 20% of the sand when removing the dried sludge.

_____ d. Scrape and smooth surface prior to application.

_____ e. Avoid sand loss.

12. Which sludge type can be loaded the heaviest on a drying bed?

_____ a. Digested primary sludge.

_____ b. Digested secondary sludge.

13. What is the major advantage of surfaced drying beds?

_____ a. Less costly to build.

_____ b. Sludge dries faster.

_____ c. Can be mechanically cleaned.

_____ d. Won't allow tomatoes to grow.

_____ e. Doesn't allow foul odors to accumulate.

14. Why should smoking be prohibited around drying beds?

_____ a. The underdrain may become clogged with cigarette butts.

_____ b. It is against the advice of the Surgeon General.

_____ c. The operator should not put anything in his mouth when handling sludge because pathogens may be present.

_____ d. Explosive gases may be present.

_____ e. None of the above.